

The Design and Performance of a Programmed Controller

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A programmed controller has been designed for operation with a Noise Adding Radiometer (NAR) for the automatic control of certain tracking station functions. These functions include the operation of the NAR, the operation of waveguide switches, and the control of the pointing of the 26-m antenna. This article describes the design and operation of the programmed controller.

The Model 601 programmed controller was designed for the automatic control of certain tracking station functions, including the operation of the NAR (Ref. 1), the operation of waveguide switches, and the control of the pointing of the 26-m antenna. The controller provides sixteen timed contact closures. The contact closures and timing are programmed by eight-level USASCII punched paper tape.

The controller consists of four functional sections: tape reader, timer, relay register, and control (Fig. 1).

The tape reader is a low-cost photoelectric unit with stepper motor drive that reads the program tape at 100 cps.

The timer section is a three-digit, double buffered, pre-settable down counter that is programmed by the time field of the instruction. When preset to the programmed time and started, it decrements at a rate of 10 Hz until it equals zero. The maximum programmable time interval is 99.9 s and the minimum is 0 s.

The relay register is also double buffered, and provides the outputs in the form of isolated contact closures. It is programmed by the pattern field of the instruction in the form of A 1 for a closed contact and A 0 for an open contact.

The control section instructs the tape reader when to read, and controls the flow of data to the timer and relay register input buffers. It recognizes E, P, S, and T as control characters, and the digits 0-9 as data characters. All other characters are ignored and not loaded. Additionally, all characters including control and data within parentheses are ignored. This allows the program tape, without affecting its operation, to contain a title, statement numbers, or any other comments that may assist an operator when the tape is punched or listed on a teletype.

The S character is a multi-purpose control character. If the front panel halt switch is in the enable position, the tape reader will stop when an S is read. When the front panel reset switch is closed, the tape advances, ignoring

all instructions, and halts on the next S character. At this point, the program may be started by closing the front panel start switch. Additionally, an alarm, that can be enabled by front panel control, is provided to signal an operator that the tape is stopped on a halt. With one S character located at the beginning of a program tape, these functions allow an operator to load a program tape at any position in the program, initialize the program tape to the beginning, and execute the program continuously, or once and halt.

The contents of the timer and the relay register are displayed on the front panel for operation verification. An additional front panel control, the mode switch, is provided to allow program checking. Each time it is closed in the step position, an instruction is read and displayed.

In normal operation, with the mode switch in the run position, as an instruction is read, the characters following a P character are loaded one at a time into the right end of the relay register input buffer. As each new character is read in, the previously loaded characters are shifted left one place. This process continues until a T or E character is read. The characters following a T are loaded into the timer input buffer in the same fashion as the relay register was loaded. Again this action continues until a P or E character is read.

When an E is read, this indicates the end of the instruction. First, the contents of the timer input buffer are loaded into the timer and, at the same time, the relays

are set; then, a few microseconds later, the timer is started and both input buffers are cleared.

The tape reader continues, reading the next instruction until another T is read. At this point, the timer is tested. If the timer has reached zero, the rest of the instruction is read and executed, and the following instruction is read. If the timer has not reached zero when the T character is read, the tape reader stops and waits. When the timer reaches zero, the tape reader restarts and finishes reading the instruction.

The program tape is normally in the form of an endless loop. The instruction format is flexible in that the time and pattern fields may be interchanged, and the data in each field are right-justified as they are read. The omission of unnecessary zeros allows the instructions to be compact. Table 1 shows some examples of various program instructions.

Figures 2 and 3 are photographs of the standard rack-mounted Model 601 programmed controller.

A Model 601 programmed controller is currently being used at DSS 13 to control the operation of an NAR, the operation of waveguide switches, and the pointing of the computer-driven 26-m antenna. Programs for the configuration include bore-sighting, on-source/off-source tracking, radio source drift curve generation, and radiometer calibration. This has been described in an accompanying article (Ref. 2).

References

1. Batelaan, P., Goldstein, R. M., and Stelzried, C. T., "A Noise Adding Radiometer for Use in the DSN," in *The Deep Space Network*, Space Programs Summary 37-65, Vol. II, pp. 66-69, Jet Propulsion Laboratory, Pasadena, Calif., Sept. 1970.
2. Gardner, R. A., Stelzried, C. T., Reid, M. S., "Radio Metric Applications of the New Broadband Square Law Detector," in this issue.

Table 1. Examples of program instructions

	Example	Instruction
1	P1111T37.5E	Close contacts 1, 2, 3, and 4 for 37.5 s. The decimal point in the time field is ignored by the controller and is inserted only for clarity.
2	P0000000000001111T375E	Functionally equivalent to example 1.
3	T375P1111E	Also equivalent to example 1.
4	P1T5E	Close contact 1 for 0.5 s.
5	TE	Open all contacts and continue to the next instruction.
6	P110T5331E	Close contacts 2 and 3 for 33.1 s. The 5 was punched in error and will be ignored.

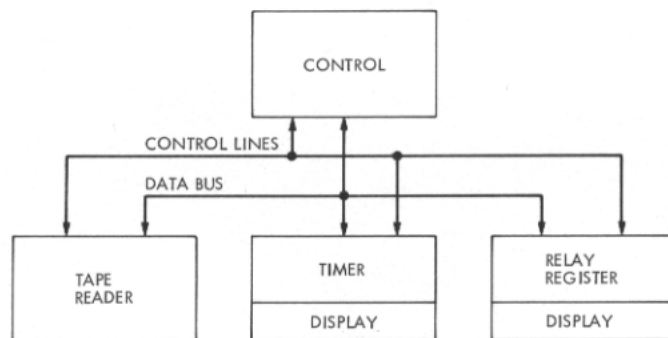


Fig. 1. Block diagram of the programmed controller

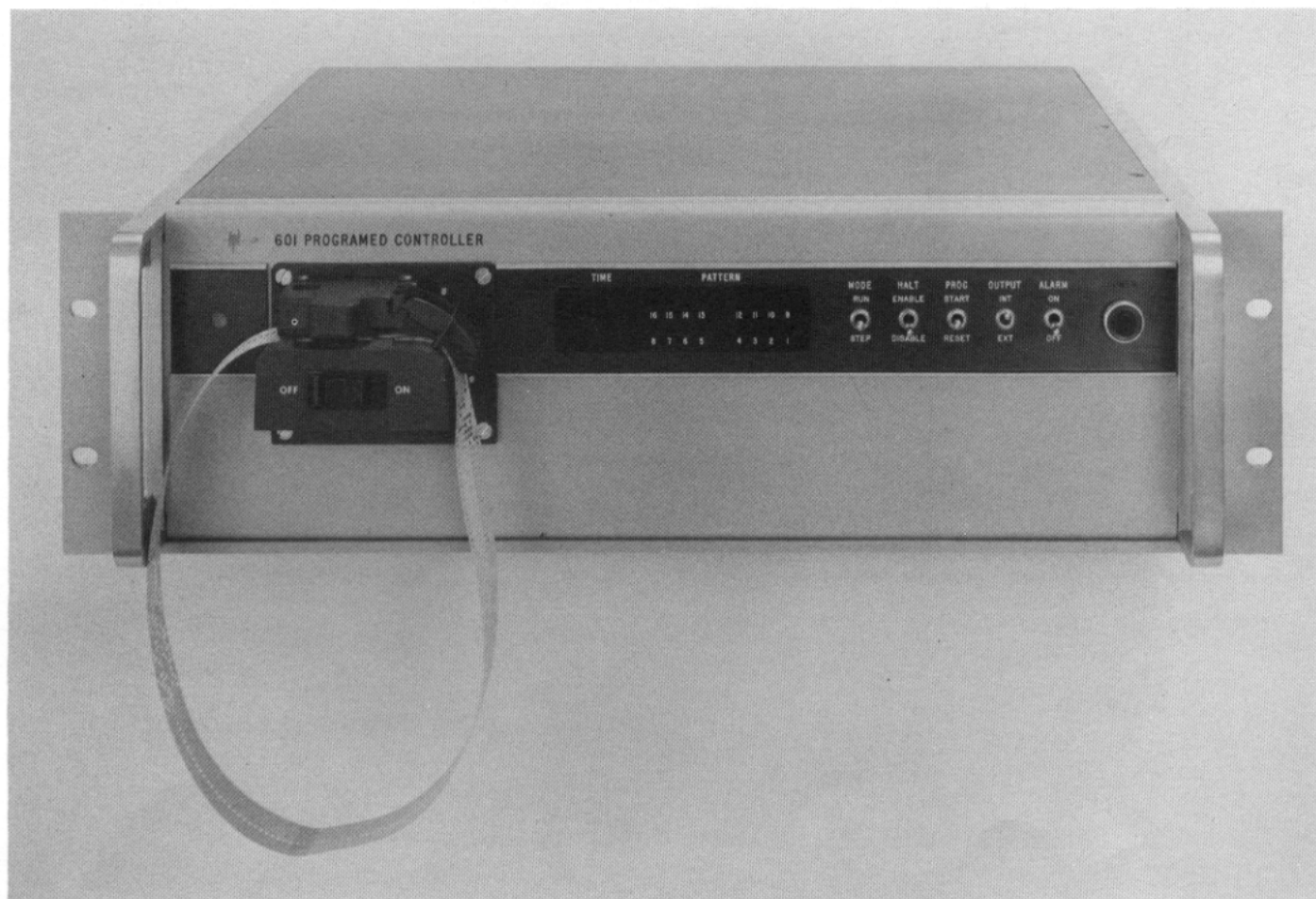


Fig. 2. Photograph of Model 601 programmed controller

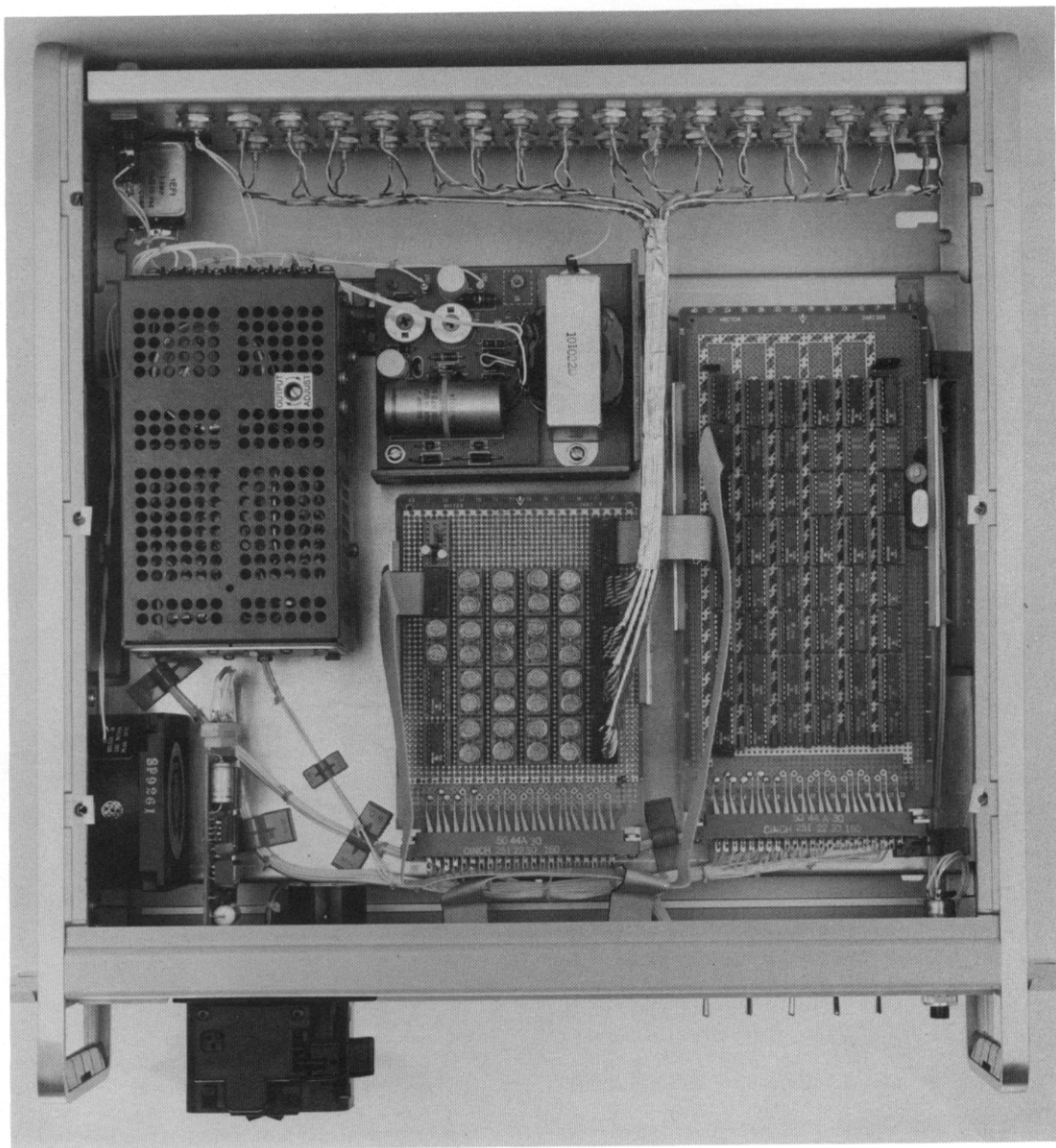


Fig. 3. Photograph of Model 601 programmed controller, top cover removed